

THE GLASGOW SCHOOL OF ART

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“Digital reconstructions and interactive visualisations of lost heritage as part of a virtual learning experience. Dissemination of heritage knowledge through digital guides and online platforms.

A case study: Mackintosh House. 6th Florentine Street.”



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This thesis is submitted in part fulfilment of the requirements for the degree of MSc in International Heritage Visualisation.

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ABSTRACT

The following project explores the use of digital technology in terms of popularizing and disseminating knowledge about lost heritage. It explores how use of latest information technology solutions can enhance learning experience by covering aspects that fail to be adequately represented with the use of traditional, non-digital means of transmitting knowledge. The general focus is given to the study of this how mobile applications integrating different recording and digital reconstruction technologies can be used to provide more complex and engaging ways of teaching about cultural heritage. Additionally, the role of online sharing platforms is being assessed in terms of making digital recordings more accessible to the public. To accurately assess the benefits of such digital tools, practical part of the project focuses on the case study of the Mackintosh House and its original premises. The history of those lost premises is introduced as a Unity engine based application that acts as a form of virtual guide. The guide is meant to enhance the visits to the Mackintosh House reassembled interiors by presenting users with additional knowledge about the building that no longer exists. Despite carefully recreated interiors, traditional exhibition at The Hunterian cannot offer the full scope of knowledge about the history of the original building that Mackintosh lived from 1906. There is a lack of sufficient visual information about the building itself. To address this problem, following project is exploring the process of creating and utilizing digital reconstruction techniques. With the use of 3d modelling software, Unity engine and some open sharing platforms, an interactive, visual guide is created. Another aim of the research is too asses the ways in which irreversibly lost context can be recreated digitally. It also reflects on the idea of this how heritage knowledge can be delivered in the context of the dynamic, highly democratized web. By using the different heritage sources, types of data, media together within virtual online environment – the researched subject can reach wider audience, and can be disseminated independently of static physical reconstructions.

1. INTRODUCTION

In anticipation of the 150th anniversary year of Mackintosh birth (BBC, 2017), the following research project focuses on the idea of applying digital technologies in terms of disseminating knowledge about Charles Rennie Mackintosh activity as an architect in Glasgow. Despite Mackintosh being figure thoroughly studied, with many of his works prominently exhibited across the city, there are still some aspects of his activity that remain less exposed to the public. Some parts of his design work are often underrepresented due to inefficiency of traditional, analogue means when it comes to covering knowledge about lost heritage. The project will analyse the ways of enhancing learning about culture with the support of Unity-based cross-platform applications. The potential gains that result from use of the innovative technology in rediscovering the work of this iconic Glasgow creator will be assessed.

The rapid developments in the sector of IT along with the emergence of dynamic web has introduced multiple opportunities and challenges for the museums and cultural institutions. Consequently, the boundaries of what can be included into visitors' experience started to reshape. Apart from including technology into their exhibitions, the heritage institutions must maintain their presence in the online environment to openly disseminate knowledge about their collection and encourage people to engage (Murphy, 2015). The idea for this project is to find an integrated approach in covering heritage knowledge with the use of digital tools. One that would address both the need of implementing engaging IT solutions as a part of physical exhibitions, and engage wider audience by using digital data sharing platforms.

Things such as interactive screens, mobile devices, applications integrating use of different software can easily present the knowledge that fails to be adequately represented while using traditional methods. Unfortunately, many of these digital tools are being commonly used as colourful gimmicks that are meant to grasp attention, slightly changing the reception texts that could be as well printed on a label. The main challenge for the curators and heritage content creators is to address what content will gain from the use of such technology. There is enormous potential in application of IT solutions in cultural sector when the needs for its use is properly identified. Lost heritage and ways of visualizing it seems to benefit the most from

the use of newest advancements in the field of IT (Murphy, 2015). While traditional physical reconstruction of sites is always going to be seen as the most immersive one, creation of them is always immensely expensive and in most scenarios not possible due to wide spectrum of issues. Modern software allows to recreate many objects digitally and utilize the screens or handheld devices to project them as a part of heritage learning within museums or other institutions.

The key concept behind this project is to explore the part of the history of the Mackintosh House that is naturally underrepresented when confronted with the care given to the reconstruction of the interiors where the couple lived. This exploration is to be turned into a mobile, virtual guide that can serve both as a part of exhibition and as well as an independent source promoting extra knowledge about this cultural site. While interiors of the architect's original house are carefully recreated and presented as a part of The Hunterian Gallery and Museum, the turbulent story of its original setting is not explored in such detail. The focus of the practical part of this project revolves around creating a digital guide presenting the history 78 Southpark Avenue (previously known as 6 Florentine Terrace) – a building that used to be an original location of the Mackintosh House. The research behind this deals with the context of the demolished site and how this lost heritage can be revived with the use of innovative technologies. This case study enables to explore an idea of redefining traditional, physical reconstruction through the addition of digital narrative.

What exists today under the name of Mackintosh House is a detailed reconstruction of the original interiors that the Mackintosh couple created in the property they owned from 1906 to 1920. The reassembled site is a part of The Hunterian Art Gallery and serves as an first-hand insight into unique design aesthetics of the Glasgow-born architect. The reconstruction that was completed in 1981 contains both original pieces of furniture, fixtures as well as copies created by through analysis of documentation that was left (The Hunterian, 2017). The great significance of the Mackintosh House results from the fact that it was one of the few last works of the late architect that embodied the notion of total work of art and one of few structures that Mackintosh had altered from both inside and outside (Grigg, 1987). The history of property had also great symbolic meaning while reflecting the fate of Mackintosh career as the architect. With the fading prospects in terms of new commissions the couple started to spend less time in their Glasgow home, regularly leaving the city and the property unoccupied. Finally, they decided to sell it in 1920 (Grigg, 1897).

1.1 Research questions

The research question for this project are centred around the potential benefits of digital reconstruction and this how new ways of documenting heritage can improve the experience of different type of audiences. The project of a virtual guide designed for the learning experience dealing with the Mackintosh House acts as a perfect way of addressing various groups. While the primary audience benefiting from the Unity-based application would be the traditional visitors to the museum premises, there is also another type of users that will potentially benefit from the knowledge gathered throughout this research. By sharing the digitized resources on the open online platforms such as Sketchfab and Round.me, the heritage knowledge about Mackintosh can reach wider circles. Many users of platforms sharing digital content can be easily exposed and encouraged to deepen their knowledge on Mackintosh by studying the digital reconstruction and engaging in online social activities. The change in web dynamics is reflected through the way we are learning today, and it demands heritage institutions to engage through creation of the digitized resources that are widely accessible. Creating digital content for the sole use of enclosed space is very limiting and undermines the potential of the digitized objects or digital reconstructions. These new innovative ways of representing heritage records are demanding more democratized access to the knowledge. The purpose of the research is to see how virtual learning experience within museum can also integrate the aspect of free dissemination of knowledge with the use of Sketchfab and Round.me services.

Apart from technical aspects, the research will naturally focus on the historical context of the Mackintosh House. The series of questions will be addressed in the Unity-based guide. What was the look of the 6 Florentine Street building before and after Mackintosh's ownership? How was the place altered and how those alterations reflected the concept of total work of art – Gesamtkunstwerk? How accurate is the actual reconstruction of the interiors presented by The Hunterian? What part of Mackintosh' vision was not finally realized? What was the public response and reactions towards the planned demolition? Covering those aspects will allow users to gain necessary knowledge to understand the missing context in the narrative regarding 6 Florentine Street.

2. LITERATURE AND BACKGROUND REVIEW

2.1 The Mackintosh House

The growing popularity of Glasgow's West End drawn more and more of middle-class citizens. Being a retreat from densely populated centre it became a desired living destination for many successful Glaswegians. Among them was the iconic artistic duo – Charles Rennie Mackintosh and his wife Margaret. At that point of Glasgow's history, it was one of the fastest developing neighbourhoods in the city. Up to the year 1906 the couple occupied the city centre flat at 120 Mains Street. The great residential development commenced in the second half of 19th century when the area of Hillhead became the burgh, and was subsequently incorporated into Glasgow in 1891 (Williamson, 1990). Florentine Terrace, the future house of Mackintosh couple, was constructed in 1860s as a response to the needs of dynamically changing social landscape of the West End of the city.

The building itself was a typical representation of the tenement stylistic. It consisted of three principal stories and an attic. According to the letters of Margaret Macdonald from 1919, the property when bought by the couple for £975 was “in a dreadful state – everything had to be renewed – drains plaster baths etc electric light had to be put in & so on ...” Further correspondence reveals the maintenance and repairs costs of £900 that Mackintoshes had to pay. (Macdonald, 1919). Apart from that they had to fill the property with their own furniture.

The most informative sources about 6 Florentine Street and Mackintosh vision of that property are architect's original drawings. In the collection of The Hunterian Art Gallery and Museum there are five architectural drawings depicting proposed alterations to the construction. One of the earliest pieces, dated for March 1906, allows to study in detail the proposed changes as the plan consist of both pre-existing plans and pencil-drawn proposed alterations. Floorplans dated from March and April of 1906 were submitted and accepted by the Dean of Guild on 12th April of 1906. The alterations proposed by the Mackintosh started to take place.

2.2 Alterations

Among many alterations such as the new front door, the external changes were limited to the windows within the south gable area. In terms of windows, the most remarkable alteration was the long horizontal first-floor window. The massive window had metal elements in frames and casements with leaded glass (Mackintosh Architecture, 2014).

The lighting and exposure of the rooms was essential in terms of Mackintosh vision. He wanted to draw a contrast between grim, outdoor Glasgow and his almost all-white, subtle interior designs. Presence of numerous windows was the simplest embodiment of this strive for luminosity (Robertson 2014). All of the alterations were meant to create a consistent space, space where there is a common visual narrative for every, even the smallest piece of furniture. This meticulous care given to the every detail, embodying the notion of 'total work of art' often resulted in Mackintosh losing a chance for his project to be ever constructed (Grigg, 1987).

Mackintosh wanted to also alter the windows of the seconds floor, but the plans were not finalized. The plans he submitted showed a tripartite window relating to the other elements of interior. Fig.1 and Fig.2 presents the scale of changes that eventually took place. From others proposed changes that were not finally introduced was an intended addition of a second-floor bedroom above the back wind. The original designs envisioned it in roughcast to correspond with the floors below.

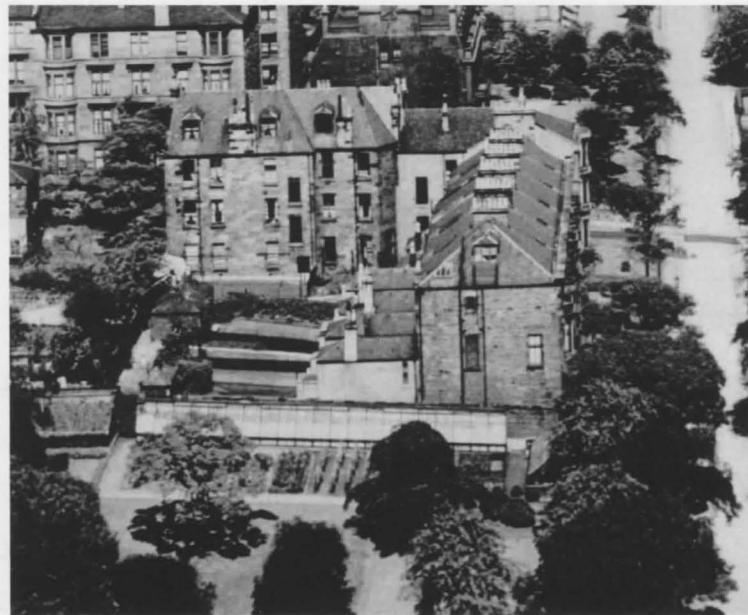


fig. 1 South view in 1905 taken by T. Annas < <http://www.mackintosh-architecture.gla.ac.uk> >



fig. 2 South view in 1937 taken by T. Annas < <http://www.mackintosh-architecture.gla.ac.uk>>

Apart from external changes, Mackintosh made some alterations on each of the floors of the building. As some of the elements were transported from his previous house at 120 Mains Street it can be said that interiors were designed in a manner that would a consistent visual narrative taking into account those objects.

2.3 Post-Mackintosh

After Mackintosh terminated his partnership with John Keppie, he was no longer bounded to Glasgow. The couple began leaving the property for longer amounts of time, from 1914 onwards when they departed for their holiday in Suffolk. (Grigg, 1987). In 1915 for example, they moved to Chelsea where Mackintosh tried to revive his career as an architect. By 1919 they have decided to sell the property to the Davidson family. Finally the property was sold to the University of Glasgow in 1943 and all of the Mackintosh belonging were donated to it by the Davidsons (Grigg, 1987).

The thread of subsidence led to the plans of demolition which took place in 1960s. In 1973 The university started working on the reconstruction of premises as a part of the new gallery placed 100 meters away from the house location (Mackintosh Architecture, 2014). The reconstruction of the interiors from the original Mackintosh House had always been present throughout the design plans for the gallery. The form of concrete exteriors of the Hunterian Gallery clearly tries to evoke certain aspects of the lost 6 Florentine Terrace structure. The reconstruction follows the original plans and spatial relations between rooms what accounts for it faithful nature (fig 3).



Fig. 3 The Mackintosh House in The Hunterian Art Gallery < <http://www.mackintosh-architecture.gla.ac.uk> >

2.2 Virtual learning for architectural heritage

The ties of digital technology and the heritage sector are constantly getting more apparent. Changing web dynamics, promoting users exchanging content provide excellent ground for dissemination of heritage knowledge. Retrievability of information is greater and potential audience can be wider. Because of the fast-growing capabilities of computers, we are now able to record and process data in greater quantities than ever before. This wide use of technology for the heritage sector resulted in creation of many more efficient ways of recording and processing data than it took place in previous decades (Champion, 2008). Technological advancement created new channels of gathering, organizing and transmitting our knowledge about culture. This digital revolution rendered data more accessible and retrievable. However, there are still numerous challenges resulting from this rapid growth. Apart from simple technicalities, such as storing or hardware dependency we need to be aware of the purpose of the data. Is the data meant only for the person responsible gathering it? What are the proper ways of sharing it, who does the digitally recorded heritage belong to?

The peculiar nature of heritage data and their shared meaning require it to be rendered accessible for the public, shareable (Addison, 2001). This in terms of non-professional audience can be achieved by creation of complex learning experiences based on dissemination

of heritage data. Within virtual environment we can create customized learning experiences. Not repressed by physical limitations – such as the geographical distance or the fact that the analysed site does not longer exist. With newest accomplishments of digital recording technology users can be provided with accurate visual reproduction of objects. By precisely addressing the need of the potential audience, we can communicate knowledge about architectural heritage to wider circles of both specialists and non-specialists.

Creating a learning experience for the heritage requires ability of organizing data in a manner that is going be logical and understandable for the audience. When applying virtual reality technology for this process one should acknowledge the specific nature of learning through digital simulation. Virtual reality in term of architectural education offers unique form of exploration. Embodied learning experiences combine aspects of both procedural and declarative learning. The user explores both the technical aspects of VR while having an opportunity to gain knowledge about architectural heritage.

The concept of “Virtual Heritage” is a leading notion when it comes to the digital preservation of culture (Addison, 2001). Virtual reality reinvents the ways of interacting with visual data through creation of a digital simulation, a digital copy or reimagination of a real-life experience. The digital technology has enabled to represent architectural concepts in a more complex way incorporating new levels of immersion. Because of the digital nature of the recordings we can copy them, manipulate and edit to create completely new virtual simulations. The dynamic technological progress has enabled to create custom digital narratives with the use of complicated visual representations. Virtual environments allowed not only to record visual data in a compact digital form but also to reinvent it. Throughout the past decades the number of different recording techniques radically increased allowing for application of virtual reality as a learning tool present user with new possibilities of experiencing visualisations. VR headset offers first person view that allows to experience the scale of the original constructions. The quality offered by this almost direct presence and interactivity creates embodied learning experience where users experience innovative way of exploring spatial nature of different sites. Users are enabled to wander around and explore the subjects in virtual environment that simulates places that without technology would remain inaccessible.

Appropriate visualisation of the gathered data is essential in creation of a successful learning experience. and ability to choose appropriate technologies for a project is essential to create an experience that is going to serve its purpose. The wide array of various technologies

dealing with recording and representation of heritage data are Visualising architectural heritage, and heritage in general within virtual environment offers unique opportunity to not only accurately represent objects but also to evoke, imitate certain ambience. The environment of virtual reality gives an opportunity to expand simple visual cognition based on experiencing images on flat screens. Learning through digital simulation becomes more immersive because of the procedural elements engaged in that process. The experience of virtual heritage even through the simplest cardboard headset without any move-tracking is still rewarding and enriching the learning process.

The complex story of the estate and Mackintosh impact on it provide an interesting challenge in terms of heritage documentation and its appropriate representation. Creating a 3D reimagination of Mackintosh's vision allows introducing new ways of learning about his distinctive style. The use of digital visualization technologies presents heritage specialists with innovative methods of communicating knowledge. The current display of Mackintosh House deals thoroughly with representation of interior spaces and role of Mackintosh as a designer. However, it lacks a representation of the lost context. This lost context is needed for a full insight into complexity of the creator's vision. Indication of the primal location and the form of the original construction require additional visualisation that will give audience a clue about the fate of the premises. Implementation of digital technologies to reimagine the original vision present audience with unique opportunity of experiencing non-existent heritage. Well-designed experience of virtual narrative can draw them closer to the idea of 'total work of art' that Mackintosh himself was promoting.

Presence of heritage content on widely accessible platforms created for and 360 photographs sharing. This multi-platform approach can attract new audiences not previously able to access heritage sites directly. Online exchange of information enables better promotion of Mackintosh and Glasgow history. With open platforms such as Sketchfab – educational content can be shared efficiently. 'Democratization of Heritage' is a phenomenon that is partially enabled by the changing dynamics of media. The freedom of accessing knowledge changes our ways of consuming it and sets new ways of operating on information.

3. Materials

Materials, or in this case - creation tools, are being used to see how efficient digital solutions can be in terms of delivering coherent source of learning. This is simply a selection of computer software that allows to create quality visual content. All the work with the digital tools is based on primary sources such as drawings and photographs, therefore the emphasis on the quality of visual options that the chosen programs offers. The visualisation, along with appropriately design user interface is implemented into game engine to act as a transferable app accessible through several types of devices.

3.1 3DS Max

Autodesk's 3DS Max software is widely acclaimed and is seen by professionals as a great tool for architectural visualisation. With its wide range of modelling tools, it offers different approaches in terms of shaping objects for virtual environments. The intuitive workflow along with personal proficiency rendered this software the primary choice for digital reconstructions. It seemed to be the best choice for reimagining original construction of the Mackintosh House. Especially, when based on hand-drawn side-plans and photographs. Those visual sources, can be easily implemented to the workflow by uploading them as additional plans that one can later model over. With its wide array of saving formats, 3DS Max allows for creation of models that are smoothly exported into Unity software. Having access to such an extensive array of plans and drawings archived by the University of Glasgow, and software that can effectively work with them led to a rewarding analysis of Mackintosh vision and a final 3D model.

3.2 Photoshop

The visual side of the interface required use of picture-editing software. What initially was, a sketched wireframe of where should the particular buttons should be placed had to be recreated within graphic software. For the creation of rather minimalistic menu elements and decorative layout Photoshop functions were enough. Despite initial attempts of designing interface features in Illustrator, vector-based workflow proved to be too demanding and unnecessary for this scale of application intended for the mobile devices. Decorative lines and characteristic roses evoking Mackintoshes' stained glass designs were easily implemented into the unity engine by creation of a selection of simple PNG graphics.

Moreover, the use of Adobe Photoshop software enabled creation of textures depicting the floorplans. These plans serve as a mean of exploration of the building layout, ensuring their clear presentation was essential for providing users with visual information that is immediately grasped. The elements of interface are referencing visual motifs present among Mackintosh drawings and designs, particularly the stained glass. Keeping consistent visual side, evoking distinctive style are important in presenting 'total work of art' concept. Introduction of some of Mackintosh style to the interface expands the visualization value beyond the 3D reconstruction itself.

3.3 360 ° Samsung Camera

360 ° Samsung camera has been used to capture images of the contemporary site along with the building that currently houses the reassembled interiors of the Mackintosh House. The photoshoot took place in front of The Hunterian Gallery to capture elements that are echoing the demolished 6 Florentine Terrace building. The 360 images were used in the final part of the virtual guide where user has a chance to explore the actual state of the premise in the modern times. The implementation of Round.me's 360 viewer is a way of utilizing open sharing platforms – a concept that allows to disseminate heritage knowledge around existing online communities of users.

3.4 Unity Engine, Sketchfab and Round.me

Unity engine allows to combine multiple ways of visualizing data and representing them within virtual environment. In this case, the Unity Engine provided a ground for a simple digital narrative uncovering the story of 6 Florentine Terrace by enabling effective visual communication with the potential audience. The creation of an effective and open form of virtual guide was possible due to easiness of building cross-platform environment that would complement the 3D model of the digitally reconstructed heritage.

Use of unity engine made it possible to create a common ground for tit with open platforms such as roundme.com. In this case, direct connection with in-browser viewer can immediately transport the user into a first-person viewpoint. After providing him with cardboard headset he can explore the 360 photographs through his own device. In the case of virtual guide for the Mackintosh House, features offered by Round.me platform would be used to present the existing exteriors of The Hunterian Gallery, the ones are meant to echo the original structure of 6 Florentine Street. Dissemination of data through different platforms such as Sketchfab and Roundme.com makes content more accessible for new audiences. It allows

users from diverse backgrounds to discover the history of Mackintosh. Those intrigued by the model, will have a chance to get familiar with its cultural significance. Both platforms introduce a part of the whole research project, by exposing it to the new audiences they encourage users for further exploration of the topic. The presence of visualisation on innovative visual data sharing platforms accounts for the interest in developing heritage learning with digital technologies. It proves how accessibility of heritage can be easily widen by integrating digital collections with already existing sharing platforms.

4. Research methods

Careful examination of plans gathered as a part of the University of Glasgow's Mackintosh Project (fig 4). along with written sources such as extracts from the Dean of Guild's archives allowed for a creation of a comprehensive virtual learning experience. The process of recreating the 6 Florentine Terrace house as a 3D model was exclusively based on plans or archival photographs.

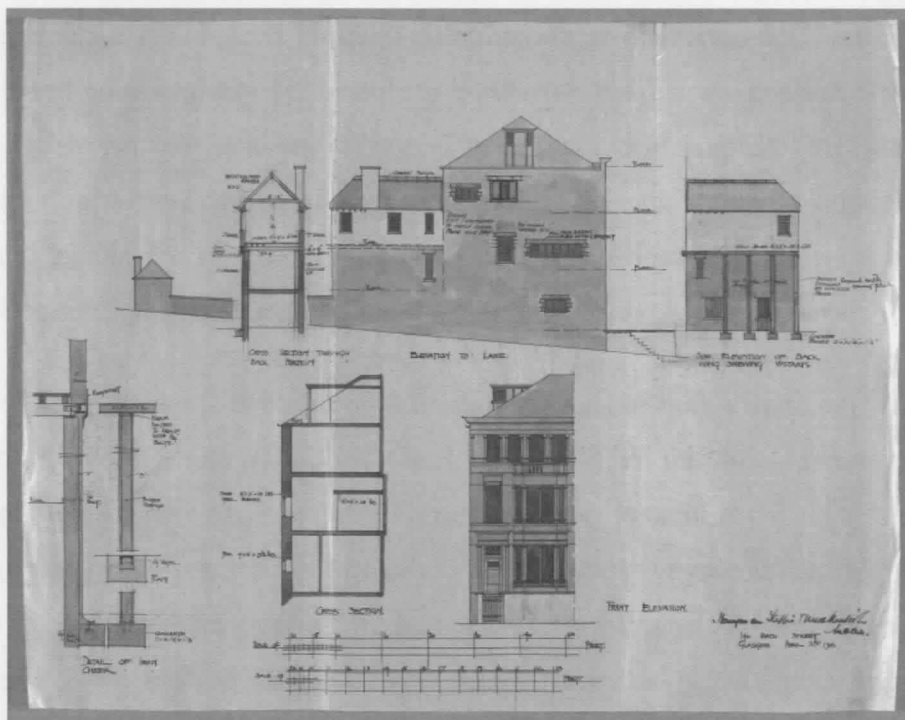


Fig.4 Example of a plan used as a reference while creating a digital reconstruction coming from the collection gathered by University of Glasgow-led project < <http://www.mackintosh-architecture.gla.ac.uk>>

The differences between plans and photographs reveal what parts of the alterations proposed by Mackintosh were implemented and which were omitted. Final model reflects all

of the changes proposed by the Mackintosh. Moreover, all of them are explained to the audience by the appropriate description within the application. As the original construction has been demolished there was no possibility of gathering new documentation or basing model on the current state of the premises. Accessibility of the 3D model can be easily granted through the Sketchfab platform. This open-source 3D viewer allows to upload models and create easy forms of navigation around it. Sketchfab was among the one of the first platforms to offer an interactive browser based way of disseminating 3D models. Introduced in 2012, it was a response to the lack of online environment where both 3D professionals and amateurs could share something more than static screenshots of their work (Sketchfab, 2017). The innovative approach of sharing digitised object perfectly addresses one of the questions that this research is trying to address – how to engage people outside of the physical boundaries of museum and widen the general audience?

One of the starting points in the creation of a functional virtual guide is to build an interactive 3D model of the exteriors of the 6 Florentine Street denoting the characteristic changes that were implemented by Mackintosh and rendered this building unique among any other tenement-style objects. Through combination of conventional 3D modelling and game engine functionalities users will be able to experience the original context of what can be found in the Hunterian Art Gallery today. The project will explore the concept of digital reconstruction within dedicated virtual environment such as Unity application along with additional media being used. The visualisation itself will be accompanied by curated descriptions and timeline denoting the most vital facts about the property.

Most of the research is based on thorough analysis of both visual and written sources. By gathering different photographs and plans of the original building's exterior and interior the model reimagining the exteriors of 6 Florentine Street is created with the use of specialist 3D modelling software – Autodesk 3DS Max. By the extensive examination of available sources faithful digital reconstruction of the missing exterior context is created to complement the experience of visiting The Hunterian's premises. The model act as a main feature around which the virtual guide would be based on. The use of visualisation will allow for the creation of a comprehensive source of knowledge about the events that led to the demolition of the original site and will offer a chance to interact with a digital reconstruction.

To see how effective virtual learning environment can be for digital reconstructions the visualisation consists of an untextured, see-through model of the building structure. The setting

itself would be explorable with the use of head mounted display – Google cardboard and simple user interface, providing an engaging way of exploring the digitized heritage. The functionality of examining the model through the cardboard headset are based on the feature available through the Sketchfab in-browser engine. With the use of Unity Engine, it will be possible to create an interactive environment that will act as a new way of digital storytelling that would engage users into exploring the lost heritage. The interface and visual style of the application are to be heavily inspired by the style of Mackintosh's drawing to reflect his commitment to the concept of 'the total work of art'. By implementation of minimalistic design principles along with subtle nodes to the Mackintosh style users will not be overwhelmed by interface and will find it easy to navigate throughout the virtual guide.

The online catalogue 'Mackintosh Architecture' created as a part of a project led by The Hunterian, University of Glasgow is a comprehensive source of images (photographs, original 6 Florentine Street plans) and documents essential for this project. Apart from digitized primary sources it also consists of an extensive description of the site and a timeline (Mackintosh Architecture, 2014). The project benefits from including an analysis of primary sources such as newspapers from 1960s referencing the issues with subsidence and the need for demolition. Numerous books regarding Mackintoshes and their design practice are used to provide accurate descriptions within the virtual guide.

For the digital reconstruction and its interactive visualization - there is a vast number of visual sources that are to be crucial in terms of digital recreation the building itself with the use of Autodesk 3DS Max software. 3DS Max proves itself as a great solution in creating content for virtual learning experiences, especially those dealing with visualisation of architecture (Autodesk, 2018). To provide appropriate theoretical background an insight into both primary and secondary sources is essential. For instance, to understand the nature of alterations made after buying the house, one can refer to letters from Margaret Macdonald Mackintosh to William Davidson. There is also a great number of academic work dealing specifically with the design stylistic that is examined in order to provide users with precise descriptions throughout the virtual guide.

The user interface design is highly inspired by the distinctive aesthetics of Mackintosh's decorative motifs. The colourful elements refer to the significance of stained glass technique present while rose symbol invokes his floral inspirations. The navigation and number of buttons

is limited to minimum to ensure users at any levels of IT knowledge can fully benefit from the app. The simple and intuitive navigation is crucial in terms of mixed audience. Both specialist and non-specialist are intended to deal with this 3D model within this virtual presentation and learn about additional contextual information regarding the Mackintosh House. Possibility of exploring it, examining selected floorplans creates an innovative learning experience that offers a comprehensive form of virtual learning by interacting with digitally displayed visuals of no-longer existing buildings. Such opportunity offered by a simple, mobile museum guide could be a first time for many of the older generation visitors to accustom with newest technology.

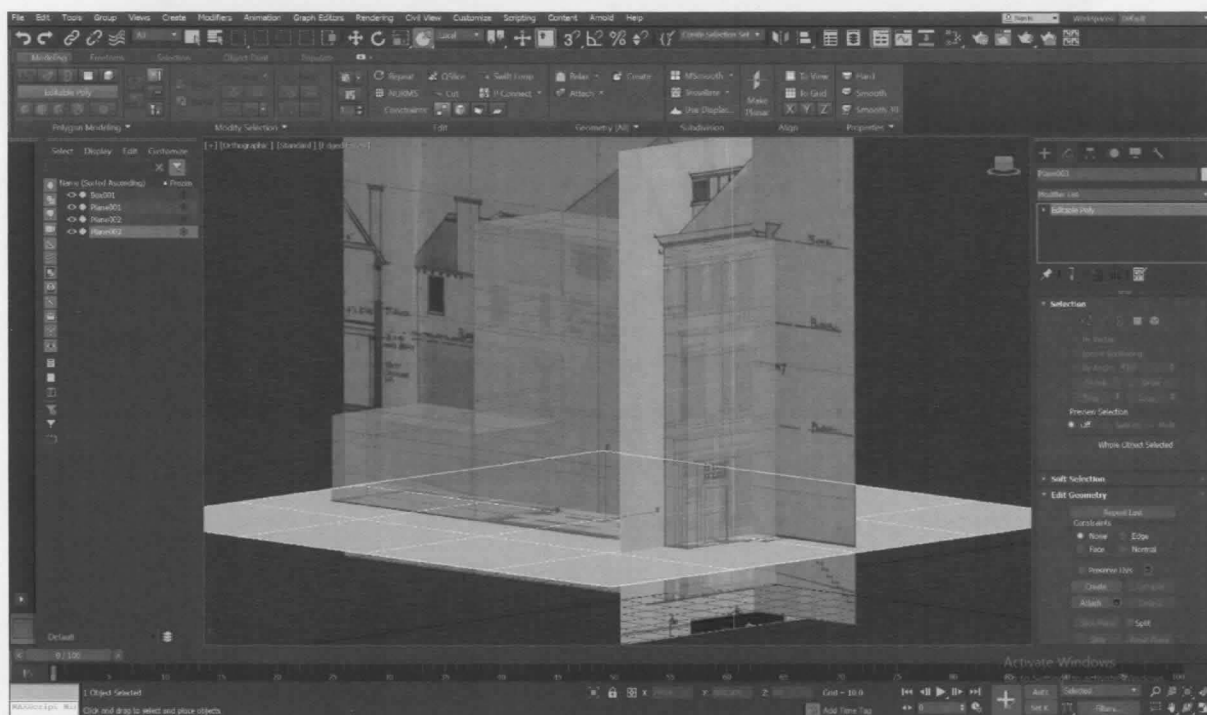


Fig 5. Screenshot depicting the workflow in 3DS MAX software

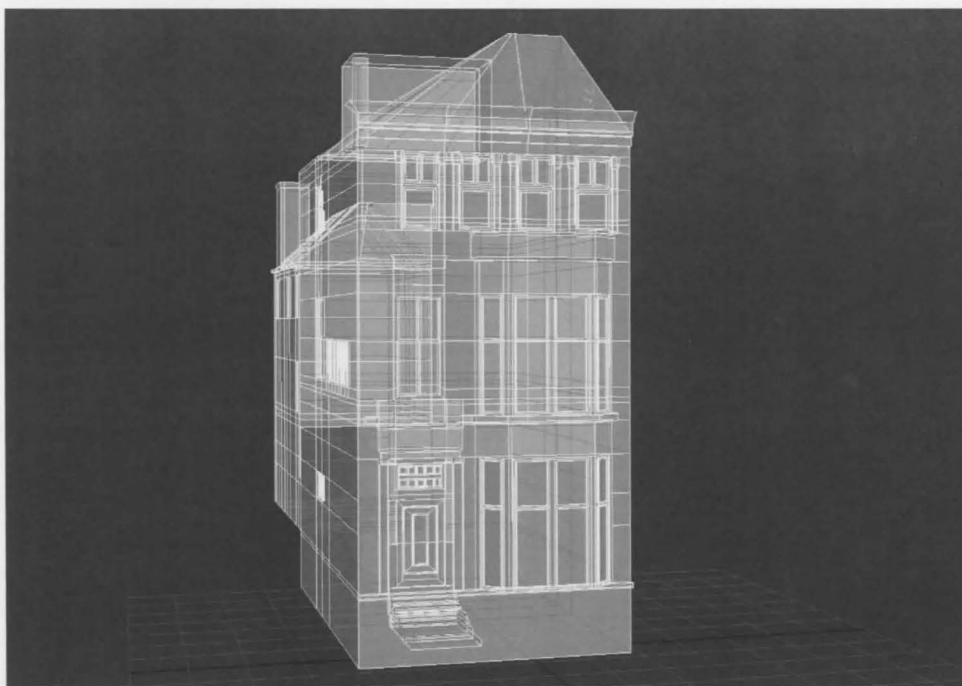


Fig 6. Screenshot depicting the workflow in 3DS MAX software

Thorough analysis of both pictures and plans Autodesk's 3DS Max software allowed for recreating the building with the wide array of modelling tools it offers. After creating two intersecting plans, the textures displaying Mackintosh original sketches were uploaded. The semi-transparent block model was created to be juxtaposed against the textured plans (Fig. 5). The shape, following the visual references, was then divided by swift loops and multiple applications of connect feature to divide selected polygons. At the same time the constant monitoring of differences between photographs and sketches was essential to track down any possible inaccuracies. Location of windows correspond to the ones indicated on the side plans and includes the vision presented by the Mackintosh in his alteration plans. The proportions between different elements were adjusted by careful measurement and recreation of scale between objects as seen in the archival photographs. This workflow allow to explore how wide array of differences between plans and photographs, giving a broader understanding of Mackintosh designing process.

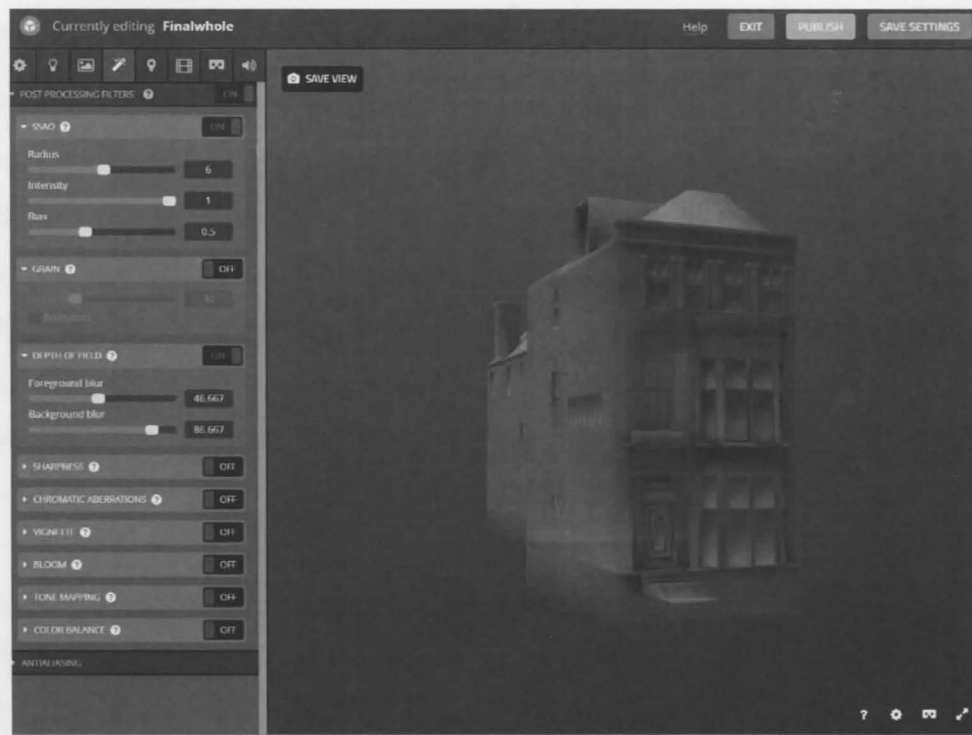


Fig 7. Screenshot of 3D model in Sketchfab in-browser viewer.

The outcome of working with 3DS Max is a clean, complex model that is can easily imported within the environment of the Unity engine and integrated with the rest of the virtual guide consisting of a textual information and other visual resources. The exploration of the model itself is possible with Unity animation system. Each floor has a corresponding model with an appropriate texture. User after picking the floor has a chance to see the photographs of interiors and further descriptions of some of the rooms and their distinctive features. At the same time user is presented with smooth access to the Sketchfab website where the model can be explored in more ways. A dedicated button simply takes the virtual guide user from the Unity-app to the in-browser 3D viewer and allows him to join the wide array of social activities such as commenting and sharing the digital content. This easily achieved connection between a shows how multi-platform approach can enrich the visitor's experience. The Unity app along with Skechtfab model should be presented on a tablet while 360 images should be made available through cardboard headsets and special link. Unity Engine provides environment where all of the different media are merged into one interactive experience telling the story of 6 Florentine Terrace history.

5. Further development and evaluation

There are many ways of improving the application in the future or using the already implemented features as starting points for creating other more complex applications. With the further study of precise plans that Mackintosh left, additional more extensive digital representations of his visions could be created. These representations could for instance show how his proposed alterations were gradually implemented throughout the years. The concept of interactive timeline explored in the virtual guide could be more engaging by including a separated model dedicated to each year or stage of alterations. Additionally, alternative models depicting the differences showing the scope of not realized redevelopment plans could be created.

Having a functional, well developed 3D model of 6 Florentine Terrace, appropriately formatted for the use within Unity game engine offer many possibilities of interacting with it. The number of these ways is constantly increasing because of more immersive technologies such as motion-tracking being integrated with VR headsets. The digitally reimaged structure of the Mackintosh House could be used as a base for a fully exportable virtual reality environment. Having exact measurements of rooms, plans with accurate scaling allows for creation of VR experience that would accurately represent more spatial knowledge about premises. Using the detailed model as a base for VR headset experience could provide users with first person viewpoint of the outside of The Mackintosh House. Addition of such feature to the visitors' visit is something that would naturally complement physical reconstruction of the interiors. Transitioning between physical and digital reconstruction with the use of advanced VR headsets would allow for an innovative and engaging learning process that fully benefits from the traditional and virtual methods. Within the application created for this project so far, this idea of transitioning is explored through with the use of features offered by Sketchfab and Round.me platforms. Experience of the virtual guide can be easily enhanced by the addition of cost-efficient cardboard headsets in order for a more immersive experience of one of the virtual representations – the digitally recreated exteriors presented in the Sketchfab viewer or 360 pictures uploaded on Round.me.

With the application of more advanced modelling and digital recording techniques such as laser scanning these representations could be even more detailed and immersive. Combining it could be used as a base for a VR environment that would contain additional representations of the interiors. As the 3D environment could be accessed with the use of more advanced, expensive VR headsets. For instance, implementation of HTC Vive headset and its motion-

tracking within expanded reconstruction could increase the immersive nature of the whole experience. With potential digital representation of interiors, users would be enabled to move around the virtual representation of the entire environment in regard to its original context.

Interiors that are a part of the Hunterian Museum and Art Gallery's collection could be digitally documented and represented within virtual environment. This virtual world could be built around the existing model. The 6 Florentine Terrace virtual structure could be filled with digital representations of existing Mackintosh furniture and serve as a comprehensive virtual depository. It would be a natural continuation of the research. Further exploration of lost context and attempt of an immersive way of representation it. Use of headset could be expanded to the whole experience and 360 images could be accompanied by animated 360 time-lapse consisting of both models and actual photographs.

The virtual guide accompanying visitors could be seen as starting point of creating digital repository of knowledge on Mackintosh heritage. By expanding the guide with more interactive visualisations it could eventually become a standalone virtual experience acting as a complex introduction into both constructed and unrealized visions of the iconic Glasgow architect. The virtual guide feature could be even more effective for the The Hunterian institution if actually applied as a learning tool on their premises. Apart from being a guide around the history of Mackintosh House it could also include information of other collections and focus on aspects that for logistic reasons fail to be adequately represented through traditional means. Apart from serving solely as a source of knowledge about Mackintosh it could also act as tool that proposes ways of applying virtual learning for audiences of different level of technical skills. The easily accustoming the audience with new forms of presenting digital data without becoming too overwhelming.

The actual process of fully integrating the application with the tour offered by The Hunterian and their exposition would require a series of permissions as well as tight working schedule that would follow the availability of supervisor from The Hunterian team. Due to logistic restrictions, this full integration was not achievable at this stage but further work on the project could result in offering more consistent and well tailored experience. The reception and usability of the virtual guide would definitely gain from it being a part of the actual tour around the Mackintosh House in The Hunterian. Simultaneous exposition to visual representations of both physical and digital reconstructions would allow users to have a broader insight into the history of the site.

The proposed evaluation of the project would have to take place under tighter cooperation with The Hunterian Museum. To effectively test the application, a mobile device would be handed to multiple visitors prior to their visit in the Mackintosh House so they could use it during their experience of the physical reconstruction of the interiors. The app would offer them augmented experience, virtual extension of their visit in a form of a handheld digital device that is about to give them a chance to get accustomed with the story of the original 6 Florentine Terrace premises. Along with the device they would be given a pair of cardboard VR headset to use the features offered by Sketchfab and Round.me. After their visit they would answer the questionnaire of this what aspects of their visit to the Mackintosh House were enhanced by the virtual learning and if would they be willing to use similar guidebooks regarding reconstructed sides in the future. Participants would be asked to assess the usability of app and technical aspects such as ease of navigating and choice of graphics.

6. Conclusion

The creation of the virtual guide project proves that there are many ways of benefiting from the use of digital tools when it comes to representing cultural heritage. With the wide array of digital solutions being present in the modern day, heritage professionals can cater to various types of audiences and can easily make the traditional forms of presenting knowledge more engaging and effective. The case study of the Mackintosh House shows how can digital reconstruction can be integrated within learning experience that is primarily based around a physical reassembling of non-existent heritage site. The simple Unity-based application that integrates the use of interactive visualization with online platforms, and introduces engaging storytelling can at a very low cost become a tool that increases the knowledge gained by the visitors. Being transferable to any type of mobile device it can act as a source of information both inside and the museum institution – dismissing the physical boundaries of building as the only learning source. Through implementation of such feature as a part of the experience of showcasing culture, curators and audience gain new mean of communication. The static text

on the leaflets can be replaced with more dynamic content that can be adjusted at a lower cost – just by updating the app.

The virtual guide could be easily modified in accordance to the advancement of the research on the particular topics, each part of the proposed app can be amended without the need for affecting the entire structure of the application. Along with the use of online sharing platforms explored such those explored throughout the project existing, digitized content can be disseminated independently of the app. By uploading visualizations or photographs to such media as Sketchfab or Round.me institutions can easily advertise their collections and engage wider audiences including both professionals and heritage enthusiasts. This dynamic nature of online environments created numerous opportunities to differentiate the methods of disseminating historical and cultural knowledge. Despite meticulous reconstruction of the interiors as a part of the Hunterian Art Gallery and Museum, there is a noticeable void in the narrative. Exploration of Mackintosh history requires appropriate visualization of the original exteriors as well. That was an excellent opportunity to utilize digital reconstruction technologies and their potential in terms of learning. Visualization enabled transmission of knowledge at various levels. As it can cater to both specialists and amateurs in different fields of human activity.

New technologies proved how many new ways of enriching visitor experience there are. Simple introduction of a dedicated mobile app can expand the knowledge gained and can easily visualize non-existent context. Unity environment or 3D models accessible through Sketchfab can be freely shared and easily explored by the users worldwide, which redefines the static nature of exhibition. The Mackintosh House turned out to be a perfect case study showing can certain things can be presented with the use of virtual media. The entire process of learning can be expanded and be more efficient.

The virtual guides or the virtual learning environments for heritage – the concept explored throughout this research – are enhancing the visitors' experience. They offer unique insight into things that cannot be simply incorporated into the actual exhibition or cannot be easily represented through printed media. The idea of introducing such medium for The Mackintosh House perfectly reflects the spectrum of benefits that application that virtual learning carries for both visitors and museum professionals. Through the introduction of digital narrative enriched by 3D models and interactive 360 photographs users can quickly switch between aspects of the lost heritage during their learning process depending on their needs.

The multi-platform approach in realisation of this project contributed to the creation of easily accessible source of digital content. Users do not have to experience whole visualisation at once, they can use its parts such as 360 gallery or model itself without any need of launching the entire app. The need for more open access to heritage knowledge is addressed in this project. This content should be open and accessible to the audience, it should engage new participants into a dialogue about heritage. Those are the principles that fully benefit from interactive, dynamic web. The project successfully proposes a way of integrating different methods of disseminating heritage knowledge in the context of objects that no longer exist. The numerous possibilities offered by the virtual learning tools enable visitors to change their perception and more effectively represent certain cultural issues. The virtual guide dealing with the history of the Mackintosh House is aimed at filling the void that results from inefficiency of traditional methods of representation heritage knowledge. It shows how digital forms of communication can benefit from traditional ones. To deliver the most rewarding learning experience digital technologies always be complementing traditional resources not try to compete with them, and that is the main concept that introduction of the virtual guide of 6 Florentine Terrace is trying to prove.

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List of Attachements:

1. Unity Application
2. Link to Sketchfab page:
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